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ABSTRACT

Aptitude-treatment interaction research is reviewed, with particular emphasis on the interaction of achievement and instructional method. Previous research has suggested that students with lower prior achievement require maximal instructional support. Recent research on this relationship is reviewed, as well as the relationship between intelligence and prior achievement. The distinction between aptitude-treatment interaction and achievement-treatment interaction is also examined. Five research studies of prior achievement and instructional method are reviewed. Three studies investigating the relationship between intelligence and prior achievement and the implications of pretesting are also discussed; a distinction is made between pre-task data and within-task variables. Researchers have recently been interested in the psychological processes underlying aptitude or intelligence testing and instruction. This concern is highly related to the achievement-treatment formulation. Directions for further research is suggested. (GDC)

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INTERACTION BETWEEN ACHIEVEMENT AND INSTRUCTIONAL METHOD

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INTERACTION BETWEEN ACHIEVEMENT AND INSTRUCTIONAL METHOD[1]

The study of aptitude treatment interactions (ATIs) is of vital importance to education from both a theoretical and practical point of view. Theoretically, better understanding of how individual differences interact with instructional methods is bound to clarify the processes that contribute to effective instruction. Practically, of course, any instructional prescription which implies that one kind of individual should be instructed with one instructional method and another individual with a different method implies the existence of well-established ATIs. The study of ATIs can, then, be seen as an important cornerstone in any science of instruction.

Cronbach and Snow (1977) have recently published a comprehensive review of ATI research, and subsequent studies have been reviewed by Snow (1976, 1977). An intensive review of studies examining the interaction between anxiety and instructional methods, and a model suggesting the directions for further research in that area have also appeared recently (Tobias, 1977a, b). Little can be gained by attempting a similar review at present. The aim of this paper is to review and clarify one aspect of ATI research: the interaction of achievement and instructional method.

Achievement Treatment Interaction

It has been suggested (Tobias, 1976; 1973) that prior achievement can be expected to interact meaningfully with instructional method. Specifically, a general hypothesis has been advanced (Tobias, 1976) that the level of prior achievement may be inversely related to the amount of instructional support required in order to attain instructional outcomes. That is, students with low prior achievement may require methods of maximal instructional support in order to achieve objectives whereas only minimal support may be needed by students with high relevant achievement. Instructional support may be generally defined as the assistance given to the learner by way of organizing the content, making provisions to maintain attention, providing feedback regarding the student's performance to the material, and monitoring achievement at a micro level from one unit to another. Prior research in support of this formulation was reviewed elsewhere (Tobias, 1976). It is the purpose of this paper to review some more recent research investigating this formulation, clarify the relationship between intelligence and prior achievement, and finally, distinguish more specifically between aptitude treatment and achievement treatment formulations.

Research Findings

Tobias and Litwak(Note 1)investigated the interaction between prior achievement and instructional method in a study using programmed instructional materials of varying familiarity to students. A total of 141 students from Catholic and Jewish parochial schools were randomly assigned to either constructed responding, reading a program in the form of completed sentences, or to a concise text version of the same content. The program dealt with synagogue rituals and was presumed to be familiar to Jewish students, and quite novel to those of Catholic background. Regression analysis indicated

that Catholic students, who had limited prior familiarity with this content, achieved most when they were assigned to the method of maximal instructional support: constructed responding with feedback. These results are displayed in Figure 1.

Insert Figure 1

Jewish students, on the other hand, who had substantial prior experience with this content, did about as well with minimal instructional support, a concise text version of the program, as they did with more elaborate instructional support offered by constructed responding. These results are depicted in Figure 2.

Insert Figure 2

Pascarella (Note 2) investigated the interaction between prior mathematics achievement and level of instructional support in college calculus. High instructional support consisted of learning this content in a personalized system of instruction (PSI) arrangement (Keller, 1968). Lower instructional support consisted of students participating in a traditional lecture recitation condition. As can be seen in Figure 3 the results

Insert Figure 3

of this study provide strong support for the achievement treatment formulation. Students with lower scores on the mathematics placement exam achieved more when assigned to the PSI condition than those assigned to lecture. At higher test score levels on the mathematics placement exam, there was no difference between the two instructional methods. This is precisely the type of ordinal interaction to be expected from the achievement treatment formulation.

Ott and Macklin (1975) studied the interaction between instructional method in a college physics course and a pretest specific to the course, as well as methematical aptitude as measured by the SAT quantitative score. Instruction consisted of an "Audio Tutorial" mastery based instructional strategy (Postlethwait, Novak, and Murray, 1972) and a standard lecture-recitation, laboratory strategy. The correlation between pretest scores and mathematical aptitude was .33. Interactions were obtained both with the mathematical aptitude score and with pretest indicating that at upper levels of math aptitude and math pretest the standard instructional strategy led to superior achievement. At the lower end of both scores the mastery based strategy was clearly superior.

Figure 4, based on data supplied in the Ott and Macklin report,

Insert Figure 4

displays the interaction between math pretest score and instructional method with math aptitude held at mean. The negative slope to these data can be attributed to the fact that pretest was scored in terms of errors. The interaction strongly supports an achievement formulation since at upper pre-test score the lecture method is clearly superior, whereas at lower pre-test score the audio tutorial method results in superior achievement.

It should be noted that in a follow-up investigation (Ott, 1976), in which a number of major changes to the instructional methods occurred, neither the interaction between pretest, nor that with mathematical aptitude was replicated. In that investigation neither of these measures were highly related to posttest when students were assigned to the method they preferred. Students tended to achieve more in the standard instructional method. Several changes in the instructional methods during the second investigation (Ott, 1976) should be noted. The lecturer in the standard

lecutre-recitation method used an "instant response system" (Littauer, 1972) which allowed the instructor to ascertain the correctness of student responses to questions asked in class and hence adapt instructional pace to student achievement. Furthermore, students assigned to the standard instructional method reported spending substantially more time per week on their course work outside of class than did the students in the audio tutorial (8.6 compared to 5 hours). Finally, 16% of the students in the individualized method indicated that they did not go to the learning center, where the individualized materials were available after the fourth week of the semester, and 53% of the students in this mode indicated irregular attendance at their class activities. Clearly, in the replication the amount of instructional support available in both methods changed dramatically rendering that study of little use in clarifying the relationship between instructional support and prior achievement.

Further support for the achievement treatment formulation comes from a study by Hansen, Ross, and Rakow (Note 3). These investigators compared four different instructional models with respect to their effectiveness in teaching mathematical material. The models employed included an adaptive model in which instructional support provided to the learner, in the form of the number of examples given, was determined individually on the basis of pretask and within task indices, and a selective model in which instructional support was determined according to the group to which the learners were classified. A number of other groups not relevant for present purposes were also used. In most of the comparisons the adaptive group performed best. Of special relevance for present purposes was the fact that in developing predictions for the adaptive model, the students' pretest scores contributed the greatest percentage of the variance compared to a number of other indices including tests of anxiety, stress, and locus of control. The data revealed

that the best predictor of the amount of instructional support required was clearly the students' pretest scores.

Prior Achievement and Intelligence

One area of the achievement-treatment formulation requiring clarification is the relationship between prior achievement and intelligence. Thus, a question may arise as to whether differences in prior achievement may actually be masking differences in intelligence. Interaction between achievement and instructional treatments, then, may actually stand in for general ability and instructional method interactions. A further question arises whether interactions with prior achievement are actually masking more complex, or higher order interactions between prior achievement intelligence and instructional treatment. This possibility is alluded to by Snow (1977, p. 13) who says that "describing this initial state involves much more than determining what each learner already knows about the content to come. Prior knowledge is important, but beyond this there are general learning and problem solving abilities (which used to be called "intelligence" and lately is again)." Fortunately, there are some data at hand that can be examined to clarify this question.

In a study by Tobias and Ingber (1976) an interaction was found between prior achievement and instructional method. In order to check on the possibility that intelligence might contribute meaningfully to this investigation, intelligence data for 82 of the original sample of 104 students were obtained. Regression analysis indicated that neither pretest, nor IQ interacted with instructional method, or with pretest in their effect on posstest, though IQ, as would be expected, did exert a significant main effect on posttest score. The results of this study, then, indicated that the interaction between pretest score and instructional method is not actually masking an interaction between intelligence and treatment, and furthermore indicate that intelligence did not meaningfully interact with pretest score and instructional method suggesting that higher order interactions between pretest score and intelligence were not

evident at least in this investigation.

Intelligence data were available for 64, out of a total of 141 subjects in the study by Tobias and Litwak (Note 1). The examination of higher order interactions with so few subjects is, of course, not too meaningful. Some relevant data did, however, emerge from the re-analysis of those results. Intelligence had a correlation of only .03 with pretest score, and .15 with the posttest score. Clearly then, whatever additional variance was contributed by intelligence in that investigation was essentially independent of the information provided by pretest. Since a significantly greater percentage of subjects in the reading group had intelligence tests scores available than in either the constructed response or text group the fact that there were no higher order interactions between intelligence and response mode, or between intelligence and pretest score is not too revealing about this overall problem.

Data from one other source are also available with respect to the contributions of intelligence to interactions between instructional method and pretest score. The Ott and Macklin (1975) study described above examined interactions with instructional method between both pretest score and SAT mathematical score. The plot of the joint interactions between these variables and instructional method indicates fairly similar interactions with both variables. Thus, students with low SAT quantitative scores, or low pretest scores appear to profit most from the audio-tutorial instructional methods, whereas those scoring high on both variables appear to do well with the standard lecture method.

While Ott and Macklin did find an interaction between mathematical aptitude and instructional method, it is important to note several points about these data. The interaction with mathematical aptitude was <u>not</u> in any way different from that with pretest score. Second, the correlation between the math aptitude score and pretest was only .33, which, while significant, nevertheless accounted for a very small percentage of the variance. Third, there were no reports of higher order interactions between mathematical aptitude and pretest scores, thus, for all practical purposes little new is added by

introducing interactions with mathematical aptitude in these data.

Perhaps the relationship between intelligence and prior achievement can be clarified by distinguishing between pre-task and within task variables. Pre-task variables consist of all those data describing the status of the student prior to the onset of instruction including information on aptitudes such as intelligence, affective states such as anxiety, as well as information on the cognitive processes customarily employed by the individual. Within task variables, on the other hand, consist of data accumulated once the individual has started to work on the instructional materials, including specific pre-test data. While pre-tests are, of course, generally obtained immediately before the onset of instruction, it can be legitimately considered a within task variable for a number of reasons. First of all, test content is highly similar to instructional content, and is assumed to have little generality beyond indicating where the student stands with regard to the instructional material. Second, pre-tests are generally administered in close temporal proximity to the instruction. Third, in situations where the instruction is in the form of a series of modules pre-tests may be embedded within instructional material, or may actually be taken during the course of instruction as the student proceeds from one module to the next. Such data then properly belong with other within task variables such as errors on acquisition, formative evaluation results on prior instructional segments, and other data on prior segments such as attitudes and time on task.

It is the major contention of the achievement-treatment formulation, that, in general, within task variables are likely to interact more meaningfully with instructional method than pre-task variables. This expectation

is based on the reasoning that data on within task variables are likely to be derived from content similar to that on which instruction actually occurs, and that the data are accumulated at points more directly relevant to the progress of instruction. It would stand to reason then, that such data ought to interact more meaningfully with different instructional methods than data gathered from points further from the instructional process, or on different content than that on which the students are being instructed. The present expectation, then, would be that those pre-task variables which are most highly correlated with within task variables are, therefore, most likely to interact with instructional method. In general, the lower the correlation between the pre-task variables and within task data the less likely would one expect pre-task variables to interact meaningfully with instructional method.

Some data pertinent to the present discussion come from a reanalysis of a study conducted by Hedl (Note 4). That study dealt with the administration of the Slosson Intelligence Test (Slosson, 1963) by computer. Available pre-task data on 52 college students included sex, grade point average, state and trait anxiety and attitudes towards computers. Within task data included the following variables on prior items: pass or fail, latencies, and length of answer to items. Stepwise regression analyses were computed for items 2 to 24 of the test, item 1 was omitted since only pre-task data were available at that time, to predict pass or fail on each item. All data accumulated prior to the item being investigated were free to enter the equation in terms of the degree to which they incremented the multiple correlation coefficient. Considering all the predictors entering the equation at a significant level a total of 114 within task variables, and only 17 pre-task variables entered all of these equations. When only the first four variables making significant contributions to the equation are con-

sidered pre-task data entered a total of six times, compared to 63 for the within task variables.

There are, of course, limits to the generality of the reanalysis of the Hedl data. The data were collected in a testing situation, not an instructional context. In the reanalysis reported above only the data for one treatment, the group receiving the test via CAI, are included. Finally, a pre-task general ability test would have been desirable, but was not available for these students. Nevertheless, the relative contributions made by the two types of variables is instructive in demonstrating how little variance pre-task variables contribute to performance once the task is underway. A similar analysis of an instructional situation would be most interesting.

Psychological Processes, Prior Achievement and ATIs

One of the most important trends in ATI research in recent years has been to investigate interactions between the psychological processes under-

lying different aptitude measures and instructional treatments. Calls for such research were made eloquently by Glaser (1972), DiVesta (1972), and a number of other investigators. This movement has paralleled the renewed interest in intelligence in general, and in research on clarifying the psychological processes underlying differences in intelligence, such as that of Hunt (1976) and a number of other researchers whose work is described in Resnik's (1976) book.

Glaser's (1972) paper was perhaps the most influential call for investigation of the interaction between differences in psychological processes and instructional treatments. In that paper a number of examples of promising avenues of research were cited, including the research of Rohwer (1971). In view of that fact, it may be appropriate to examine some subsequent developments in Rohwer's research as it bears on the degree to which clarifying psychological processes is of value in instructional research.

Rohwer[2] (1976) summarized the results of a number of studies which attempted to clarify the psychological processes involved in the elaboration phenomenon. In earlier work Rohwer demonstrated that the recall of paired associates could be facilitated by encouraging subjects to elaborate, that is, form a semantic or visual link, between paired associated items. A series of experiments were designed to test the general hypothesis that performance on such tasks was associated with developmental differences from pre-adolescence to adulthood. Generally, in this research, the experimental conditions consisted of differences in the amount of instructional support provided to perform the paired associate task. Minimal support occurred in the condition in which students were told merely to learn the paired associate. Greater instructional support was implied when subjects were asked to construct sentences linking the paired associate members. Maximal support was assumed to occur when students were actually provided with sentences linking the paired associate stimuli

In the first of a series of studies, Rohwer and Bean (1973) assumed that the performance of younger subjects would be facilitated by providing maximal instructional support, whereas that of older subjects should improve minimally since it was assumed that these subjects had well-developed elaboration strategies of their own. The results of most direct relevance for present purposes failed to support these expectations since maximal support facilitated both the performance of older and younger subjects. In a replication of the study using students from an upper-middle class area with presumably higher scholastic aptitude, initial expectations were strikingly confirmed. Sixth graders' performance with maximal instructional support was about 21% higher than under standard conditions, while in the older sample, instructional support did not facilitate performance significantly.

In a subsequent study instructional support in the form of imagery was compared to minimal support in the standard condition and another condition. The results indicated that the imagery support condition was superior for younger and older subjects.

In these previous studies Rohwer and his colleagues had assumed that age differences were sufficient to classify subjects according to the degree to which instructional support was required to improve performance in the paired associates tasks. The inconsistent results suggested that a more precise measure might be needed, hence, in a subsequent investigation differences in IQ were used (Rohwer, 1976). It was predicted that maximal support might be required for younger students, whereas for high IQ older students, no differences minimal and maximal support were expected. Results did not support these expectations since support in the form of sentences yielded higher performance at all intelligence levels for all age groups.

In a further study subjects were classified with respect to proficiency in the performance of a paired associate task, and in terms of age level.

Results of this study were strongly in accord with expectations. The performance of students with low paired associate proficiency, as determined by pretest under standard conditions, was significantly facilitated by maximal instructional support in the form of elaborative sentences whether they were 10 or 17 years old. For a highly proficient subject at the older age level there was little difference between the minimal support of the standard condition, and the additional support of elaborative sentences. Results for subjects of medium paired associate proficiency were in the intermediate position.

This series of experiments is instructive in a number of respects. First of all, it suggests that clarification of psychological processes underlying performance on a number of tasks may be more complex than may been expected. Clearly, much further research will be needed to clarify the reasons for inconsistent results. The second point made by these studies was that indices remote from the task, such as developmental level and IQ, were not very successful in predicting which instructional conditions facilitated performance optimally. The variable which was most successful for such a prediction was performance on what has been called here a within task variable. The series of investigations by Rohwer and his colleagues gives strong support for the position that the best index for predicting the amount of instructional support required in order to attain objectives is the pretest.

The preceding discussion is <u>not</u> intended to suggest that research on the clarification of the psychological processes involved in variety of tasks, and their relationship to traditional individual difference measures is fruitless. Clearly, such research has extremely exciting prospects of providing a firm base in psychological theory for psychometrically defined individual difference measures. Pursuit of such research should lead to clarification of what such widely used aptitude tests actually measure,

and allow psychologists at long last, to avoid the tautology that intelligence is what intelligence tests measure.

Practically speaking, the research on psychological processes offers even more exciting possibilities. Once the processes underlying performance on aptitude tests are clarified, research can be initiated to determine whether direct instruction of students on these processes can in fact improve performance. Such investigation has many interesting prospects for educational psychologists, and may perhaps in the future, make the nature-nurture controversy irrelevant.

The final point to be made by Rohwer's investigations and the others summarized in this report is that clarification of the psychological processes underlying task performance may not be essential to the development of an instructional theory. The establishment of a series of replicated ATIs which have some generality would obviously be an important component of any theory of instruction. It would permit researchers and practitioners to make generalizations regarding which instructional strategy different types of students can be assigned to. The position advocated in this paper has been that use of within task measures such as pretests, and other indices close to the instructional task are of considerable promise for the prediction of which method leads to optimal achievement. The hypothesis of an inverse relationship between prior achievement on such closely related tasks and the amount of instructional support required has received considerable research support from a variety of sources, and offers a promising avenue for advancing research on the interaction between individual differences and instructional treatments.

It is perfectly clear that the achievement treatment formulation is not independent of concerns about psychological processes. If the achievement treatment hypothesis can receive continued research support the fact that methods of greater instructional support are required by students of low

prior achievement strongly suggests that these students may in fact use different psychological processes for work on such tasks. Such students must, obviously, be more attentive and more concerned with details than students with more substantial prior exposure to the task. What difference in psychological processes is implied by these differences is at present a moot point. What is being suggested, however, is that progress in the understanding of such interactions, and their practical application does not have to await clarification of the difference in psychological processes implied by these prior achievement differences.

A final problem in adapting instructional strategies to the cognitive processes employed by students rests in the complexity of much of the instructional content taught in schools. Research on the isolation of cognitive processes typically employs materials which have been carefully analyzed so as to assure that the processes studied are likely to be engaged and the operation of other processes carefully excluded. This situation is hardly analogous to the type of instruction occuring in most classrooms beyond early elementary school levels. The elementary school curriculum engages many different psychological processes in the minute to minute and hour to hour shifts of instructional events in classes. Designing an instructional strategy relying largely on one psychological process for a subject matter as "simple" as second grade social studies, math or spelling becomes an impossible task since a large variety of processes are likely to be engaged by the instructional material.

It is perhaps only very early in the elementary school curriculum when letters and a sight vocabulary are acquired, and basic number concepts and operations taught that different instructional tracks can be designed which rely on different psychological processes. While process research may do a great deal to clarify the basic dimensions of individual differences

this analysis suggests that it is likely to make a much more limited contribution to the development of instructional strategies and materials.

When, on the other hand, instruction is designed to accommodate to students' differences on within task variables the difficulties alluded to above do not arise. Since student standing on within task variables, whether they consist of pretest or acquisition data, is monitored at a point in time and with materials quite close to that used in instruction the psychological processes engaged by the instructional content are likely to be similar to those required for performance on the pretest, and those indicated by the acquisition data. In that sense the use of within task data is similar to employing a "dummy" variable, since within task indices stand in for the particular processes employed in that segment of instruction.

Employing within task indices also opens up another avenue of research on the identification of processes. Is it possible that there is some similarity, across different subject matter, in the psychological processes engaged at differing pretest levels? While different subject matter engages different psychological processes there may also be some intra-individual consistency in the processes a student employs determined by his prior achievement in the subject matter irrespective of content differences. Is it possible that as knowledge and intellectual skills in different domains are acquired there is some regularity within students regarding the processes used in terms of the students' prior familiarity with that subject matter, their confidence in it, and their affective reaction to it? Such differences, if they should be demonstrated, are likely to be tapped by pretest and other acquisition data. Instructional adaptations based on within task variables would, then, automatically be relevant to the processes employed at different pretest levels.

Footnotes

1. Presented at the annual convention of the American Educational Research Association, Toronto, March 1978. Preparation of this paper was supported by the Institute for Research and Development in Occupational Education, Center for the Advanced Study of Education, CUNY.

2. The discussion of Rohwer's research relies heavily on the summary of the studies provided on Rohwer's chapter (1976).

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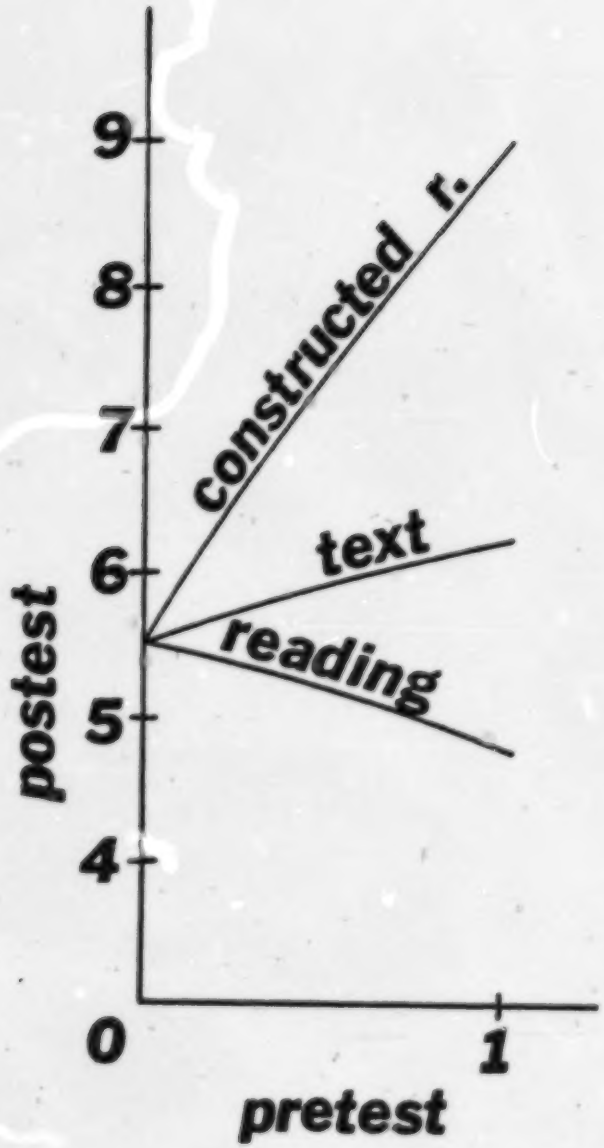
Figure Captions

Figure 1. Interaction among response modes and pretests on posttest for Catholic students. From Tobias and Litwak (Note 1).

Figure 2. Interaction among response modes and pretest on posttest for Jewish students. From Tobias and Litwak (Note 1).

Figure 3. Mathematics preparation X level of instructional support interaction .From Pascarella (Note 2).

Figure 4. Interaction among math pretest and achievement from two instructional methods. Based on data from Ott and Macklin (1975).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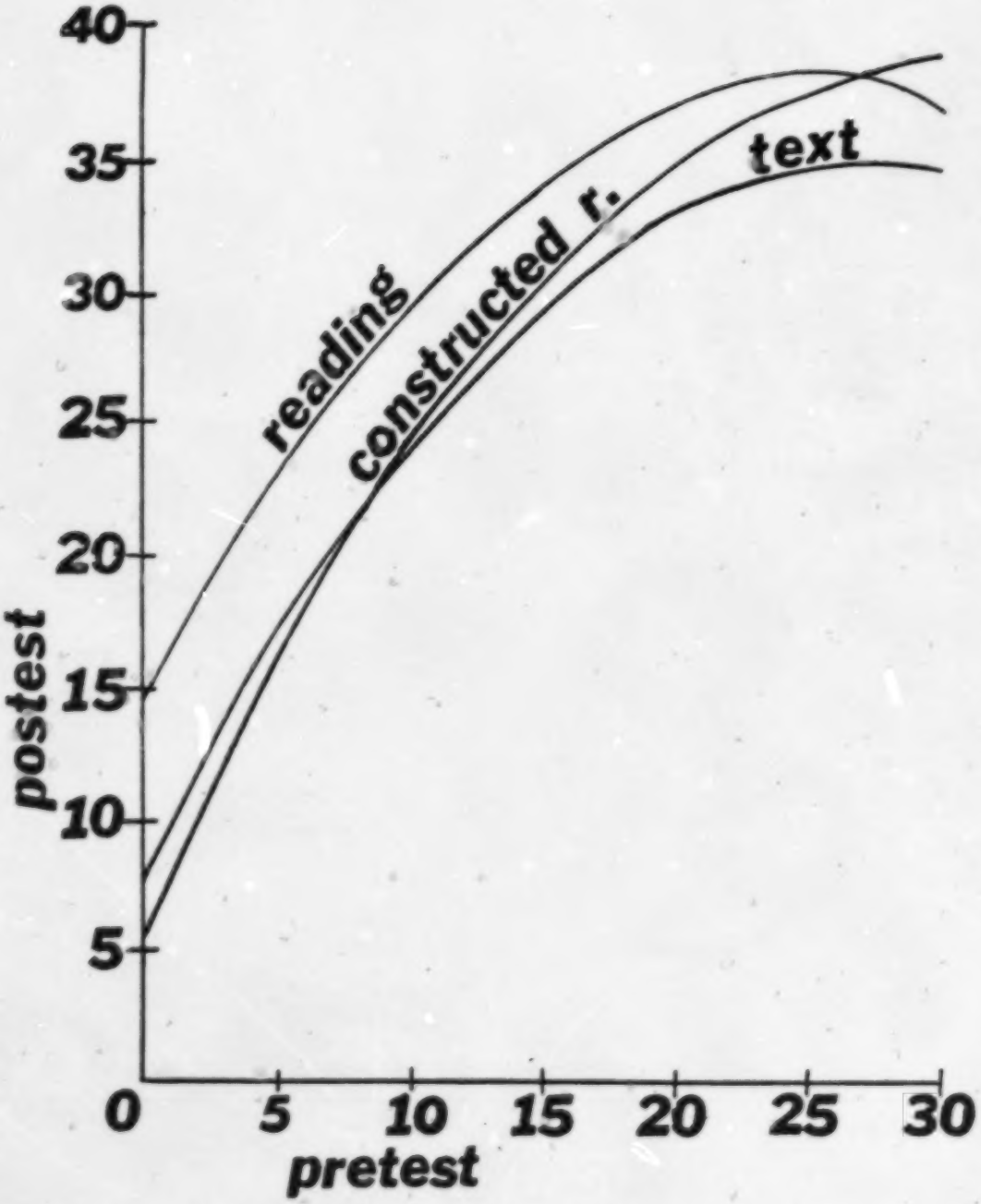
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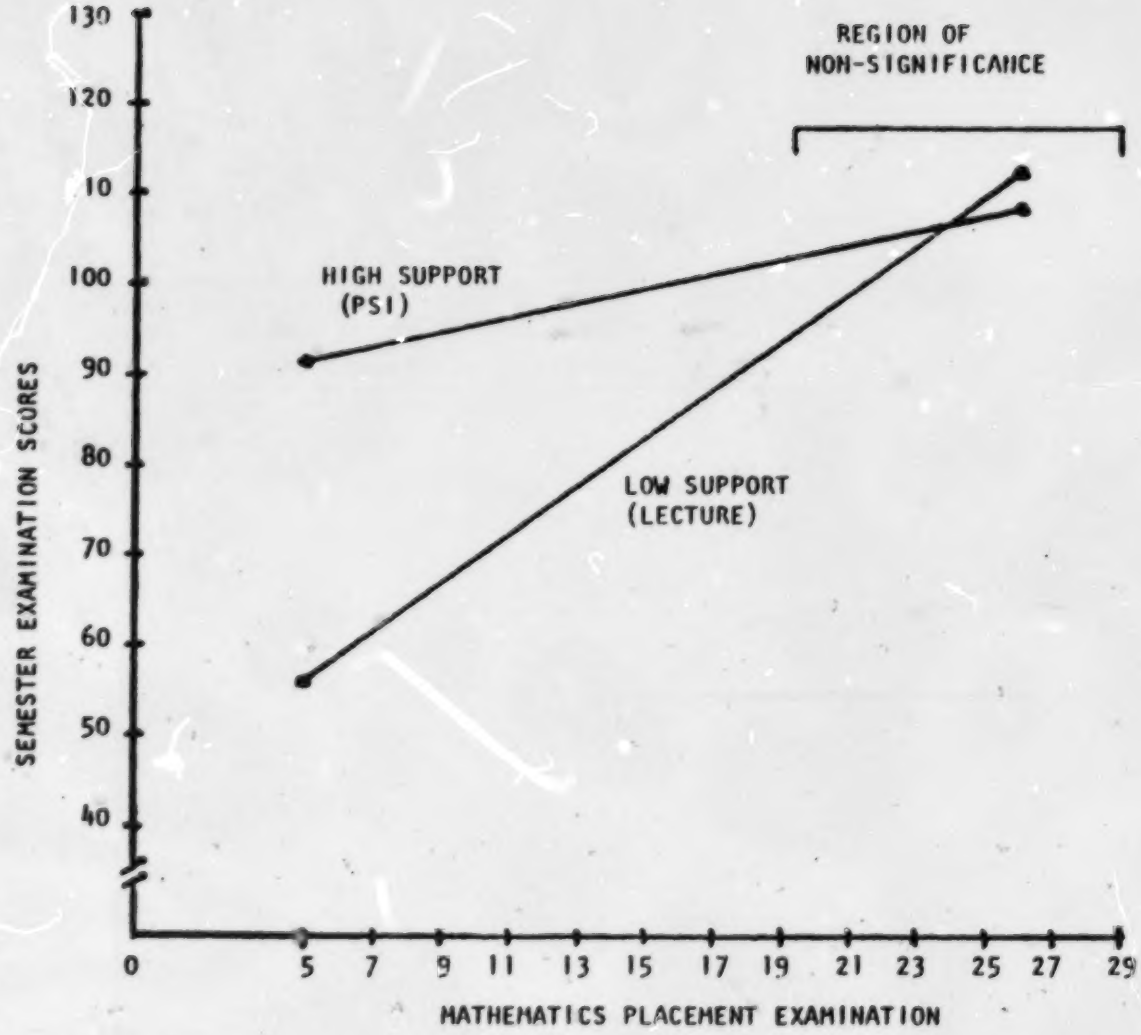
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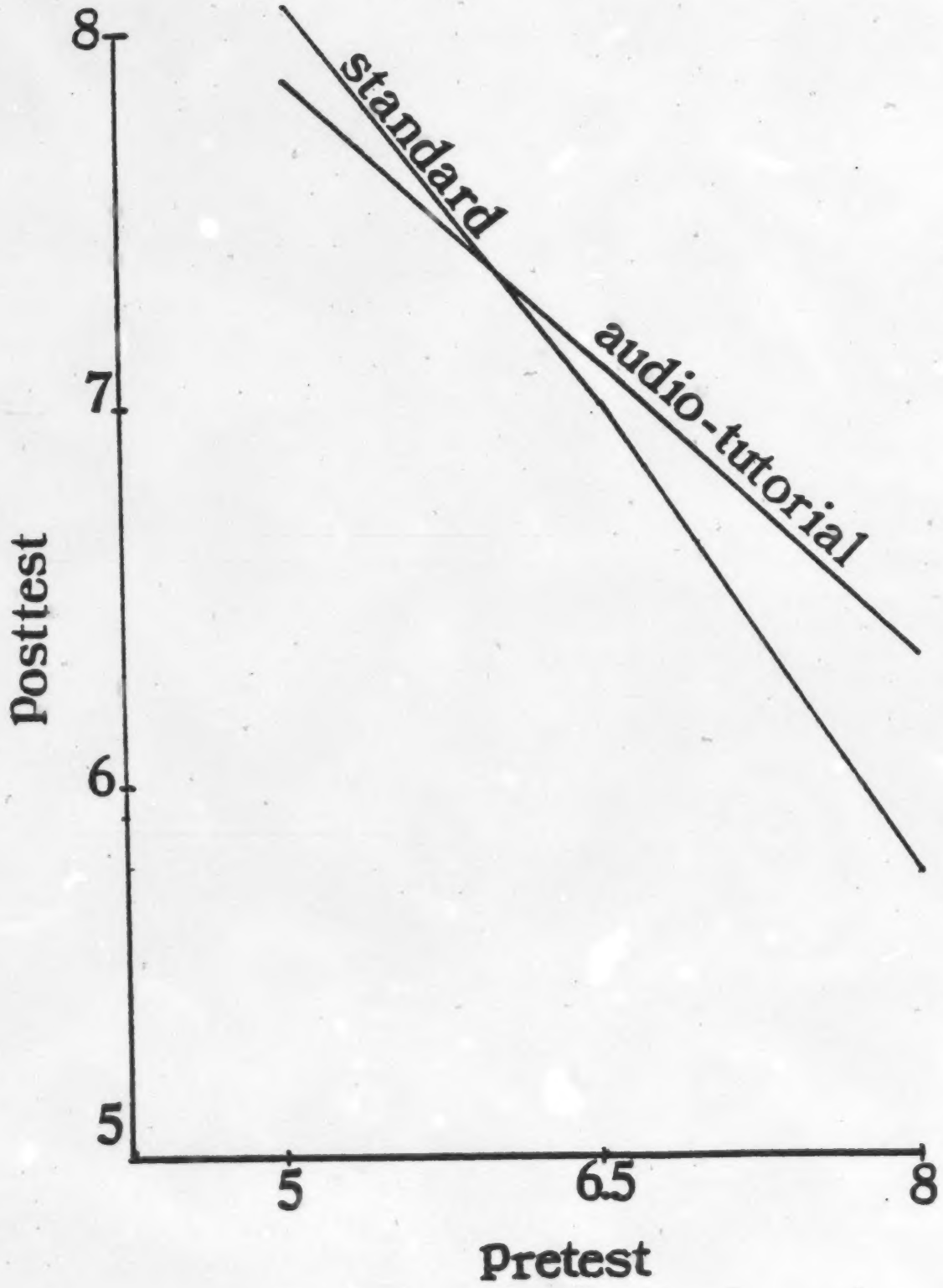
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